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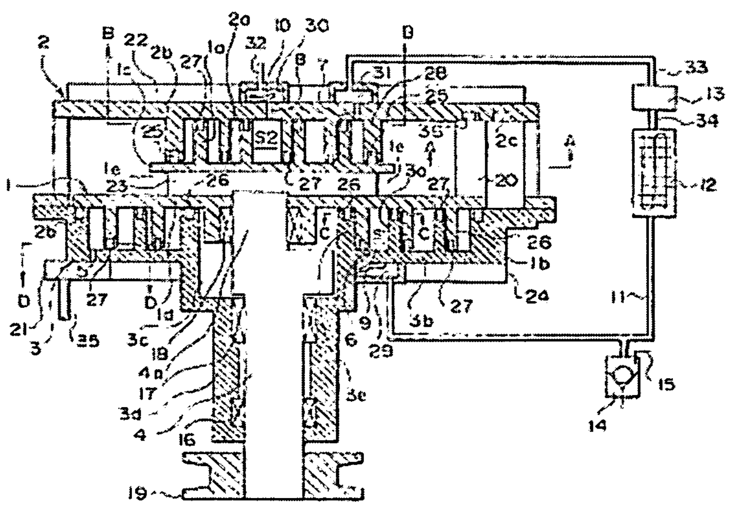
(54) **Two stage scroll compressor**

(57) A two-stage air-cooled, oil-free scroll compressor comprising a scroll mechanism for compressing fluid, includes a first stage 1, 3 and a second stage 1, 2 scroll mechanism, fluid having been compressed in the first stage scroll mechanism being further compressed in the second stage scroll mechanism for discharging.

Check valve means 9, 10 are disposed between the first stage and second stage scroll mechanisms and on the discharge side of the second stage scroll mechanism, for preventing the reverse flow of outside fluid into the compression chambers S1, S2 when the fluid pressure in the compression chambers of the scroll mechanisms is lower than the outside pressure of said compression chambers.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to air-cooled oil-free scroll compressors for improving the compression efficiency and durability of scroll compressors.

Description of the Related Art

In a prior art scroll compressor, fluid in a sealed space which is defined by revolving and stationary scroll laps or by drive and driven scroll laps, is compressed with progressive volume reduction of the sealed space as the sealed space being displaced from the outer periphery of the laps which are spiral in shape, and the compressed fluid is discharged through a discharge port provided in a central part of the scroll compressor.

Such scroll compressors generate less noise and are less vibrated compared to reciprocal compressors, while being based on rotary compression in operational principle and high in compression efficiency. Thus, they are recently finding applications to air compressors and many other industries concerning the compression of refrigerant gas in freezers, vacuum generators and so forth.

Fig. 7 shows a prior art vacuum pump using a twin oil-free scroll compressor.

In this vacuum pump, a revolving scroll which has laps each provided on opposite surfaces of a scroll body, is disposed between one side and opposite side of stationary scrolls. One of the two laps is engaged with a lap provided on one surface of one of the stationary scroll, and the other lap is engaged with a lap provided on one surface of the other stationary scroll.

Referring to Fig. 7, in a vacuum pump body generally designated by reference numeral 126, a space is defined by two stationary scrolls 127A and 127B. In this space, a twin revolving scroll 128 is disposed.

The stationary scroll 127A has a lap 137 having a spiral form. The stationary scroll 127B has a lap 138 having the same form.

The revolving scroll 128 has laps 139 each formed on each surface of its disc-like body and engaging with each of the laps 137 or 138 in 180-degree out-of-phase therewith.

The laps 139 of the revolving scrolls 128 each have a groove formed in the tip, and the laps 137 and 138 of the stationary scrolls 127A and 127B each have a groove formed in the tip. A self-lubricating tip seal 31 having an involute form is fitted in each of the grooves noted above to maintain gas tightness between sealed space compressed with the volumes thereof reduced progressively and adjacent sealed space.

An end wall of a disc-like body of each stationary scroll 127A and 127B which faces with the mirror-finished surface of the plate of the revolving scroll 128 and forms the surface of a wall accommodating those laps 137, 138 and 139, has also a groove formed in the tip.

In this groove, a ring-like self-lubricating dust seal 132 is fitted to maintain the gas tightness between a sealed space accommodating the laps and the outside, and preventing intrusion of dust particles into the sealed space.

The stationary scroll 127A has an outer peripheral suction port 129 for sucking gas, and also has a nearly central discharge port 135 for discharged compressed gas.

Likewise, the other stationary scroll 127B has an outer peripheral suction port 130 for sucking gas, and also has a nearly central discharge port 136 for discharging compressed gas.

The revolving scroll 128 has an eccentric shaft 145 which is coupled to the rotor of a motor 144, and also has three crank pins 143 which are supported at positions radially spaced apart by 120 degrees with the eccentric shaft 145 as the center.

With the rotation of the shaft 145, the revolving scroll 128 is revolved, without being rotated, with a fixed radius of revolving around the center of the laps of the stationary scrolls 127A and 127B.

The shaft 145 has a fan 146 for cooling the stationary scroll 127A with cooling fins 127Aa provided thereon.

The shaft 145 also has a fan 147 for cooling the stationary scroll 127B with cooling fins 127Ba provided thereon.

With the above construction of the vacuum pump body 126, when the shaft 145 is rotated by driving the motor 144, gas is sucked through the suction ports 129 and 130.

Gas taken through the suction port 129 is progressively compressed in a sealed space defined by the stationary scroll 127A and one lap 139 of the revolving scroll 128, and discharged through the discharge port 135.

Gas taken through the suction port 130 is also progressively compressed in a sealed space defined by the stationary scroll 127B and the lap other 139 of the revolving scroll 128, and discharged through the discharge port 136.

A sealed vessel 102 is connected via ducts 104 and 105 to the suction port 129 of the stationary scroll 127A.

The sealed vessel 102 is also connected via ducts 104 and 106 to a three-way valve 108, which is in turn connected to the suction port 130 of the stationary scroll 127B.

The discharge port 136 of the stationary scroll 127B is communicated with the duct 121, through which compressed gas can be discharged to the outside.

The discharge port 135 of the stationary scroll 127A is led to a duct 119 to a three-way valve 9, through which compressed gas can be discharged to the outside.

Further another inlet/outlet ports of the three-way valves 108 and 109 are communicated with each other via a duct 120.

An Electric controller 103 has an output terminal connected via a wiring 112 to an electromagnetic valve of the three-way valve 108, via a wiring 113 to an electromagnetic valve of the three-way valve 109, via a wiring 110 to the motor 144, and thus it can operate the three-way valves 108 and 109 and control the motor 144.

Referring to Fig. 7, the electric controller 103 first communicates the discharge port 135 with the outside by controlling the three-way valve 109 and communicates a discharge end 102a of the sealed vessel 102 and the suction port 129 of the stationary scroll 127A with each other by controlling the three-way valve 108.

When the motor 144 is driven at a predetermined rpm, a first stage evacuating pump part which is constituted by the revolving scroll 128 and the stationary scroll 127A, and a second stage evacuating pump part which is constituted by the revolving scroll 128 and the stationary scroll 127B, are operated in parallel.

Gas sucked directly from the discharge end 102a of the sealed vessel 102 through the ducts 104 and 105 and suction port 129, discharges compressed gas from the discharge port 135 through the three-way valve 109 to the outside.

Also, gas sucked from the discharge end 102a of the sealed vessel 102 through the ducts 104 and 106, three-way valve 108 and suction port 130, discharges compressed gas from the discharge port 136 through the duct 121 to the outside.

In a predetermined period of time, coarse evacuation to a vacuum of about 10^{-2} Torr is made, whereupon the electric controller 103 communicates the ducts 119 and 120 with each other by sending a control signal to the three-way valve 109.

The electric controller 103 also blocks communication between the sealed vessel 102 and the suction port 130, and communicates the suction port 130 and the duct 120 with each other by sending an electric signal to the three-way valve 108.

As a result, the first state evacuating pump part constituted by the revolving scroll 128 and the stationary scroll 127A and the second stage evacuating pump part constituted by the revolving scroll 128 and the stationary scroll 127B, are connected in series.

As the operation of the vacuum pump proceeds, the pressure in the sealed vessel is reduced, that is, the vacuum degree therein is increased. With increasing vacuum degree in the sealed vessel, the pressure of gas taken into the sealed space of the vacuum pump body is reduced to increase the compression ratio that is required for compressing gas up to the atmospheric pressure for discharging to the outside.

In the above prior art vacuum pump, in which the first and second evacuating pump parts are connected in series, the compression ratio is doubled to reduce time required for compressing the gas up to the atmospheric pressure for discharging to the outside.

In the above scroll compressor, fluid in the sealed space defined by the scroll laps is compressed as the sealed space is progressively reduced in volume and displaced from the outer periphery of the spiral laps, and compressed gas is discharged from the central discharge port.

This means that when the pressure in the discharge port is higher than the pressure in the final sealed space, which results from the initial sealed space, reverse flow of the discharged fluid back to the final sealed space takes place.

In such a case, dust particles or moisture contained, if any, in the fluid in the reverse flow, would cause damage to the scroll lap surfaces and reduce the compression efficiency of the scroll machine.

This scroll machine, in which gas in the sealed space is led toward the center of the machine as it is progressively compressed, poses another problem that the compression of fluid causes temperature rise in the sealed space between the laps, thus promoting the deterioration of bearings, seals, etc. in driven parts. Heretofore, the scrolls are cooled to suppress temperature rise beyond a predetermined temperature.

A well-known cooling system is, as shown in Fig. 7, a non-driven part cooling system, in which the stationary scrolls 127A and 127B are cooled by the fans 146 and 147.

In this non-driven part cooling system, however, the revolving scroll 128 which is disposed between the two stationary scrolls 127A and 127B, can not be directly cooled by the fans 146 and 147, so that it is difficult to reduce the high temperature generated in the sealed space.

A further problem is that gas in the sealed vessel to be evacuated readily contains moisture, because the temperature at which water is gasified is reduced with increasing vacuum degree.

As the gas containing moisture is compressed in the sealed space, the moisture is liquified into water drops. These water drops are not discharged from the discharge part but remain in the sealed space, hammering the lap surfaces defining the sealed space. This phenomenon is called water hammer phenomenon, causing damage to the Lap surfaces and generating noise.

A further problem in the scroll compressor, in which a first stage and a second stage compression mechanism are connected in series, is posed by compressed fluid that is present between the two compression mechanisms. When the scroll compressor is started while compressed fluid is present between the two compression mechanisms, the load on the scroll compressor is increased to increase drive power consumption. In addition, the load increase reduces the durability of the machine

OBJECT AND SUMMARY OF THE INVENTION

In order to overcome the above drawbacks inherent in the prior art, the invention has an object of providing a scroll compressor, which can prevent discharged fluid from flowing back into the final sealed space and reducing the compression efficiency of the scroll machine.

Another object of the invention is to provide a scroll compressor, in which cooling is done efficiently.

A further object of the invention is to provide a scroll compressor, which can remove generated water drops.

A still further object of the invention is to provide a scroll compressor having a two-stage scroll mechanism, which can suppress load increase to reduce drive power consumption and improve durability

According to a first aspect of the invention, an air-cooled, oil-free scroll compressor for compressing fluid and discharging the compressed fluid to the outside, which comprises:

> check valve means (9, 10) are disposed on the discharge side of compression chambers (S1, S2) of a scroll mechanism for preventing from the reverse flow of above outside fluid into the above compression chambers when the fluid pressure in the compression chambers of the scroll mechanism is lower than the outside pressure of the above compression chambers.

According to the first aspect of the invention, the scroll mechanism for compressing fluid is effectively a two-stage air-cooled, oil-free scroll compressor including a first stage scroll mechanism (1, 3)) and a second stage scroll mechanism (1, 2), fluid having been compressed in the first stage scroll mechanism being further compressed in the second scroll mechanism for discharging, the check valve means (9) being disposed between the first stage and second stage scroll mechanisms.

According to the first aspect of the invention, the scroll mechanism for compressing fluid is effectively a two-stage air-cooled, oil-free scroll compressor including a first stage and a second stage scroll mechanism, fluid having been compressed in the first stage scroll mechanism being further compressed in the second stage scroll mechanism for discharging, the check valve means (9 and 10) being disposed between the first stage and second stage scroll mechanisms and on the discharge side of the second stage scroll mechanism, respectively.

In this scroll compressor, fluid in the sealed spaces defined by the scroll laps, is compressed as the sealed spaces being progressively reduced in volume and moved from the outer periphery of the laps, which are spiral in shape, and the compressed fluid is discharged through a central discharge port provided outside the sealed spaces.

When the pressure in final sealed spaces resulting from the above sealed spaces is lower than the pressure outside the sealed spaces, the discharged fluid flows back into the final sealed spaces.

The check valve means which is disposed between the first stage and second stage scroll mechanisms or on the discharge side of the second stage scroll mechanism, prevents the reverse flow of fluid discharged from the sealed spaces. Without reverse flow of fluid, dust particles and moisture contained in the fluid neither causes damage to the scroll lap surfaces nor reduce the compression efficiency of the scroll machine.

According to a second aspect of the invention, a two-stage air-cooled, oil-free scroll compressor is provided, which comprises a scroll mechanism for compressing fluid, the scroll mechanism including a first stage and a second stage scroll mechanism each constituted by a revolving scroll and a stationary scroll, fluid having been compressed in the first stage scroll mechanism being further compressed in the second stage scroll mechanism for discharging, the revolving scroll (1) including:

> a first disc (1d) and a second disc (1c) spaced apart a predetermined distance from each other;
> a cooling air passage space (1e) formed between the first and second discs (1d and 1c);
> a first lap (1b) and a second lap (1a) formed on the first (1d) and second discs (1c) on the side thereof opposite the cooling gas passage space;
> the first stage scroll mechanism (1, 3) being constituted by the first lap (1b) and a first lap (3a) of the stationary scroll (3) engaging with the first lap (1b), the second stag scroll mechanism (1, 2) being constituted by the second lap (1a) and a second lap (2a) of the stationary scroll (2) engaging with the second lap (1a).

With the above construction according to the second aspect of the invention, the first and second discs (1d, 1c) of the revolving scroll (1) is directly cooled by cooling air that is forced by fins (23) to pass through the cooling air passage space (1e), resulted in having a nice cooling efficiency.

According to a third aspect of the invention, a two-stage air-cooled, oil-free scroll compressor is provided, which comprises a scroll mechanism for compressing fluid, the scroll mechanism including a first stage and a second stage scroll mechanism, fluid having been compressed in the first stage scroll mechanism being further compressed in the second stage scroll mechanism for discharging, the scroll compressor further comprising:

> heat exchanger means (12) are disposed between the first stage and second stage mechanisms, for removing heat from fluid discharged from the first stage scroll mechanism.

In this scroll compressor, as fluid is progressively

compressed in the sealed spaced defined by the laps while being moved toward the center, the temperature in the sealed spaces between lap is raised by compression of the fluid.

Compressed gas at the elevated temperature is fed from the first stage scroll mechanism to the second stage scroll mechanism and thence the second stage scroll mechanism is fed from a small room (31) for further compression for discharging through a discharge port (8).

The heat exchanger means (12) which is disposed between the first stage and second stage scroll mechanism is fed from a small room (31), cools the compressed fluid fed to the second stage scroll mechanism. Thus, temperature rise beyond a predetermined temperature can be suppressed to put down progress of deterioration of bearings, seals, etc. provided in driven parts due to high heat.

According to the third aspect of the invention, water separator means is effectively disposed downstream the heat exchanger means, for preventing introduction of moisture into the second stage scroll mechanism.

With these construction, the water separator means (13) is provided downstream the heat exchanger means between the first stage and second stage scroll mechanisms. It is possible to prevent intrusion of moisture into the second stage scroll mechanism.

Cooling of compressed fluid in the heat exchanger means causes condensation and liquefaction of water vapor in the compressed fluid by robbing heat from the water vapor

However, fluid which is fed to the second stage scroll mechanism after water content separation by the water separator means, is dry and without water content. Thus, further compression of this air in the sealed space of second stage scroll mechanism, does not result in generation of any water drop due to liquefaction. It is thus possible to eliminate the water hammer phenomenon that water drops that would otherwise be generated in the sealed spaces remain there without being discharged through the discharge port and hammer the lap surfaces defining the sealed spaces to cause damage thereto and generate noise

According to a fourth aspect of the invention, a two-stage air-cooled, oil-free scroll mechanism is provided, which comprises a scroll mechanism for compressing fluid, the scroll mechanism including a first stage and a second stage scroll mechanism, fluid having been compressed in the first stage scroll mechanism being further compressed in the second stage scroll mechanism for discharging, the scroll compressor further comprising:

> fluid discharging means (14) are disposed between the first stage and second stage scroll mechanism, for suppressing load increase due to compression fluid entering the second stage scroll mechanism.

With this construction according to the fourth aspect of the invention, at the start of the scroll mechanism, the residual fluid that is left between the first stage and second stage scroll mechanisms after the previous driving of the scroll mechanism, is discharged to the outside using the fluid discharging means, thus reducing the pressure in the space between the two scroll mechanisms. It is thus possible to prevent high load of the residual compressed fluid from being applied to the scroll mechanism, thus preventing drive power consumption increase and also preventing durability deterioration of the machine due to load increase.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view showing an embodiment of the scroll compressor according to the invention;
Fig. 2 is a side view showing a revolving scroll in the embodiment of the invention;
Fig. 3 is a view taken along line A-A in Fig. 1;
Fig. 4 is a view taken along line B-B in Fig. 1;
Fig. 5 is a view taken along line C-C in Fig. 1;
Fig. 6 is a view taken along line D-D in Fig. 1; and
Fig 7 is a schematic view showing a scroll compressor in the related prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the invention will now be described in detail. It is to be construed that unless particularly specified the sizes, materials, shapes, relative position and so forth of components described in connection with the embodiment have no sense of limiting the scope of the invention but are merely exemplary.

The embodiment will now be described with reference to Figs. 1 and 2. Fig. 1 is a sectional view showing a two-stage air-cooled oil-free scroll compressor embodying the invention. Fig. 2 is a side view showing a revolving scroll.

Referring to these figures, reference numeral 1 designates a revolving scroll, which includes disc 1c having a spiral lap 1a and a disc 1d having a spiral lap 1b The discs 1c and 1d are coupled to each other by a plurality of intervening fins 23 which define a cooling air passage space 1e for air cooling.

Cooling air is forced by a fan (not shown) into the space 1e from the upper left or right in Fig. 1.

The spiral laps 1a and 1b each have a tip groove formed in the tip, and self-lubricating tip seals 27 are each fitted in each tip groove such as to be in frictional contact with the opposed mirror-finished surfaces, thus defining sealed spaces with the laps.

The spiral lap 1b has a greater number of turns than the spiral lap 1a. These laps are rotatable at the same axis and made integral at the axis.

The disc 1d of the revolving scroll 1 has three posts 20 provided adjacent its outer periphery at a radial internal of 120 degrees and each end carrying a rotatable

roller 36 at the free end.

A pan-shaped first stage stationary scroll 3 is disposed on the side of the disc 1d of the revolving scroll 1, and its bottom 3b has a suction port 5 provided adjacent the outer periphery.

A suction filter 21, from which fluid is led form fluid source or a vessel to be evacuated (not shown) via a duct 35 for being sucked through the suction port 5, and a plurality of cooling fins 24, are provided on the bottom 3b adjacent the outer periphery thereof.

The first stage stationary scroll 3 has a central space 3c defined by a bottom deeper than the peripheral bottom 3b and a peripheral wall 3e. The peripheral wall 3e has a groove formed in its tip or top opposite the bottom, and a self-lubricating tip seal 26 is fitted in the groove.

The bottom 3b has a discharge port 6 formed near the peripheral wall 3e.

On the outlet side of the discharge port 6, a small room 29 is provided, and a check valve 9 of a lead valve type is provided in the small room 29.

The bottom 3b has a spiral lap 3a provided on the inner side. The lap 3a extends from the vicinity of the discharge Port 6 and is engaging with the lap 1b of the revolving scroll 1. The lap 3a has a groove formed in the tip, and a self-lubricating tip seal 27 is fitted in the groove and in frictional contact with the opposed mirror surface of the disc 1d of the revolving scroll 1.

The central space 3c of the first stage stationary scroll 3 has a bearing section 3d, and axially spaced-apart bearings 16 and 17 are provided in the bearing section 3d. A drive shaft 4 is rotatably supported in the bearings 16 and 17.

The drive shaft 4 has an eccentric shaft 4a as an end portion. The eccentric shaft 4a is rotatably fitted in the revolving scroll 1 via a bearing 18, and can cause revolving of the revolving scroll 1.

The drive shaft 4 has a pulley 19 mounted at the other end and rotatable from a motor (not shown).

A second stage stationary scroll 2 is disposed on the side of the disc 1c of the revolving scroll 1, and it has a stationary disc 2b with a plurality of cooling fins 22 provided on the outer surface. The stationary disc 2b has a perpendicular spiral lap 2a provided on its inner mirror surface and engaging with the lap 1a of the revolving scroll 1.

The stationary disc 2b has a circular groove 2c formed in the inner surface, and the rollers 36 carried by the posts 20 provided on the disc 1c of the revolving scroll 1 adjacent the outer periphery thereof, are fitted for revolving in the groove 2c.

The posts 20, rollers 36 and groove 2c, constitute a revolving mechanism, which permits revolving of the revolving scroll 1 driven by the eccentric shaft 4a with respect to the stationary scrolls 2 and 3 while preventing rotation of the revolving scroll 1.

The stationary disc 2b has a peripheral wall 28 surrounding the lap 2a. The peripheral wall 28 has a tip groove, and a self-lubricating tip seal 25 is fitted in the groove.

The tip seal 25 is in frictional contact with the mirror-finished surface of disc C of the revolving scroll 1 and holding the gas tightness of the space inside the peripheral wall 28.

The stationary disc 2b being formed in its portion outside the lap 2a in the peripheral wall 28 has a suction port 7 near the peripheral wall 28 and a discharge port 8 in the central portion of the peripheral wall 28.

On the outlet side of the discharge port 8, a small room 30 is provided. A check valve 10 is disposed in the small room 30, and a duct 32 leading to the outside is provided on the small room 30.

On the inlet side of the suction port 7, a small room 31 is provided, which s connected to a water separator 13 via a duct 33.

The water separator 13 is connected to an air-cooled heat exchanger 12 via a duct 34.

The heat exchanger 12 is connected via a duct 11 to a small room 29, through which the first stage side compressed gas is discharged.

A release valve 14 with a discharge duct 15 is provided between the heat exchanger 12 and the small room 29.

The release valve 14 serves to cause discharge of compressed air retained in the duct 11 after stopping the operation of the scroll compressor and thus alleviates the load at the time of the start, and it is operable according to an external signal or by a mechanical system.

In the operation of above-mentioned embodiment, the check valve of lead valve type is used as the means to prevent the reverse flow of fluid, but the ball valve is also used for them.

The means to prevent the reverse flow is provided in the small room 29 or 30, but it is also all right to provide in the passage of discharge port 6 or 8.

The fluid discharging means (release valve) 14 is provided in the duct 11, but for example, it could have the same effect, even if it is provided in the duct 33 or the suction port 7 of second stage scroll mechanisms.

The operation of the embodiment having the above construction will now be described.

Since the small room 29 is in communication with the duct 11, the check valve 9 in the small room 29 holds the discharge port 6 closed when the pressure of fluid remaining in the duct 11 is higher than the pressure in the sealed space S1 in the first stage scroll mechanism.

Prior to the driving of the revolving scroll, the release valve 14 is operated to discharge the fluid remaining in the duct 11 through the discharge duct 15.

The drive shaft 4 is rotated by the pulley 19, which is coupled to a drive source (not shown).

Since the eccentric shaft 4a as an end portion of the drive shaft 4 is rotatably fitted in the revolving scroll 1, the revolving scroll 1 is revolved. As for the scope of

the revolution, since the roller 36 carried by the post 36 provided on the revolving scroll 1 adjacent the edge thereof is restricted by the groove 2c in the stationary scroll 2c, the revolving scroll 1 is revolved about the center of the stationary scroll.

Fluid being passed via filter 21 from a fluid source (not shown) connected to the duct 35 is sucked through the suction port 5 (Fig. 6).

The fluid is taken in the sealed space S1 defined by the lap 1b of the revolving scroll 1 and the lap 3 of the stationary scroll 3 in the first stage scroll mechanism.

With the driving of the revolving scroll 3, the volume of the sealed space S1 is progressively reduced to compress the fluid into compressed fluid.

The compressed fluid pushes the check valve 9 disposed in the small room 29 and is discharged into the small room 29.

The compressed fluid is led through the duct 11 into the heat exchanger 12 and cooled down. Moisture content is thus condensed and separated from the compressed fluid by the centrifugal separating action of the water separator 13. The resultant dry compressed gas is led through the duct 33 into the small room 31 in the second stage stationary scroll 2.

As has been shown, since cooled compressed fluid is led to the second stage scroll mechanism, it is possible to suppress temperature rise beyond a predetermined pressure, thus suppressing the progress of deterioration of bearings, seals, etc in driven parts due to high heat.

In addition, since the water separator means 13 is provided downstream the heat exchanger means between the first stage and second stage scroll mechanisms, it is possible to prevent intrusion of moisture into the second stage scroll mechanism and led dry compressed fluid be introduced.

Specifically, cooling compressed fluid by the heat exchange means has an effect of condensing and liquefying water vapor in the compressed fluid by lobbing heat of the water vapor.

Even in this case, the water content is separated by the water separator means, and dry fluid enters the second stage scroll mechanism. Thus, no water drop due to liquefaction is generated by further compression of this air in the second stage scroll mechanism, and it is possible to eliminate the water hammer phenomenon that water drops that would otherwise be generated in the sealed spaces and remain there without being discharged through the discharge port, hammer the lap surfaces defining the sealed spaces to cause damage thereto and generate noise.

At the start of the scroll mechanism, residual compressed fluid that remains between the first stage and second stage scroll mechanisms after the previous driving of the scroll mechanism, is discharged to the outside using the fluid discharging means, thus reducing the pressure in the space between the scroll mechanisms. It is thus possible to prevent high load of the residual compressed fluid from being applied to the scroll mechanism, thus preventing drive power consumption increase and also preventing durability deterioration Of the machine due to load increase.

Since the small room 30 and the duct 32 are in communication with each other, the check valve 10 in the small room 30 of the second stage scroll 2 holds the discharge port 8 closed when the pressure in the duct 32 is higher than the pressure in the sealed space S2 of the second stage scroll mechanism.

As shown in Fig. 4, compressed fluid introduced from the first stage scroll mechanism into the small room 31, flows through the inlet port 7 into the space defined by the peripheral wall 28 to be taken in the sealed spaces S2 and S2' with the driving of the revolving scroll 1, and the compressed fluid is discharged into the duct 32 by pushing the check valve 10 disposed in the small room 30.

With the provision of the check valve on the discharge side of the second stage scroll mechanism, reverse flow of fluid discharged from the sealed spaces is prevented. Without reverse flow of fluid, dust particles and moisture contained in the fluid neither causes damage to the scroll lap surfaces nor reduce the compression efficiency of the scroll machine.

As has been described in the foregoing, in this embodiment the revolving scroll 1 includes the disc 1c having the spiral lap 1a and the disc 1d having the spiral lap 1b, the discs 1c and 1d being coupled together by a plurality of fins 23 defining the cooling air passage space 1e, through which cooling air is passed. The discs 1d and 1c of the revolving scroll 1 thus can be directly cooled, and efficient is obtainable.

The cooling effect can be promoted by the stirring of the cooling air in the space 1e with the revolving of the revolving scroll 1.

Also, in this embodiment the laps 1a and 1b of the revolving scrolls 1 and 1b have the self-lubricating tip seals 27 fitted in their tip grooves and in frictional contact with the opposed mirror surfaces, thus forming the gas-tight sealed spaces together with the laps. Also, the lap 3a on the inner surface of the bottom 3b, spirally extending from the vicinity of the discharge port 6 toward the outer periphery, is engaging with the lap 1b of the revolving scroll 1, and it has the self-lubricating tip seal 27 fitted in its tip groove and in frictional contact with the mirror surface of the disc 1d of the revolving scroll 1. Further, the laps 1b and 3a of the first stage scroll mechanism are surrounded by the inner surrounding wall and the peripheral wall 3e of the stationary scroll 3 with the self-lubricating tip seal 26, and the lap 1a and 2a of the second stage scroll mechanism are surrounded by the peripheral wall 28 of the stationary scroll 2 with the self-lubricating tip seal 25. Sealed spaces are thus formed by the wall surfaces of the laps and the mirror surfaces opposed by the tip seals, and the tip seals prevent leakage from between the contact surfaces and permits oil-free scroll mechanism driving.

Moreover, in this embodiment the laps of the first stage scroll mechanism has a greater number of turns than the laps of the second stage scroll mechanism, and that the sealed spaces in the second stage scroll mechanism are formed such that a volume of compressed fluid equal to or less than the volume of fluid compressed in the first stage scroll mechanism is taken in the second stage scroll mechanism. Thus, in the stable operating stage, while fluid under a constant pressure is taken in the first stage scroll mechanism, the compressed fluid that is fed from the first stage scroll mechanism to the second stage scroll mechanism, is not expanded until it is taken in the second stage scroll mechanism after being discharged from the first stage scroll mechanism. Without expansion of the compressed fluid, the compression efficiency is not reduced.

Claims

1. A scroll compressor for compressing fluid and discharging compressed fluid to the outside, said scroll compressor comprising:

   check valve means (9, 10) disposed on the discharge side of a compression chamber (S1, S2) of a scroll mechanism (1, 2, 3) for preventing the reverse flow of above outside fluid into said compression chamber when the fluid pressure in said compression chamber of the scroll mechanism is lower than the outside pressure of said compression chamber.

2. The compressor according to claim 1, wherein said scroll mechanism for compressing fluid is a two-stage air-cooled, oil-free scroll compressor including a first stage (1, 3) and a second stage (1, 2) scroll mechanism, fluid having been compressed in said first stage scroll mechanism being further compressed in said second scroll mechanism for discharging, said check valve means (9) being disposed between said first stage and second scroll mechanisms.

3. The compressor according to claim 1, wherein said scroll mechanism for compressing fluid is a two-stage air-cooled, oil-free scroll compressor including a first stage (1, 3) and a second stage (1, 2) scroll mechanism, fluid having been compressed in said first stage scroll mechanism being further compressed in said second stage scroll mechanism for discharging, said check valve means (9, 10) being disposed between said first stage and second stage scroll mechanisms, and on the discharge said of said second stage scroll mechanism, respectively.

4. A two-stage air-cooled, oil-free scroll compressor comprising a scroll mechanism for compressing fluid, said scroll mechanism including a first stage (1, 3) and a second stage (1, 2) scroll mechanism each constituted by a revolving scroll (1) and a stationary scroll (2, 3), fluid having been compressed in said first stage scroll mechanism being further compressed in said second stage scroll mechanism for discharging, said revolving scroll including:

   a first (1d) and a second disc (1c) spaced apart a predetermined distance from each other;
   a cooling air passage space (1e) formed between said first and second discs; and
   a first (1b) and a second lap (1a) formed on said first and second discs on the side thereof opposite said cooling gas passage space;
   said first stage scroll mechanism (1, 3) being constituted by said first lap (1b) and a first stationary scroll lap (3a) engaging said first lap;
   said second stage scroll mechanism (1, 2) being constituted by said second lap (1a) and a second stationary scroll lap (2a) engaging said second lap.

5. A two-stage air-cooled, oil-free scroll compressor comprising a scroll mechanism for compressing fluid, said scroll mechanism including a first stage (1, 3) and a second stage (1, 2) scroll mechanism, fluid having been compressed in said first stage scroll mechanism being further compressed in said second stage scroll mechanism for discharging, said scroll compressor further comprising:

   heat exchanger means (12) disposed between said first stage and second stage scroll mechanisms, for removing heat from fluid discharged from said first stage scroll mechanism.

6. The compressor according to claim 5, which further comprises water separator means (13) disposed downstream of said heat exchanger means (12), for preventing introduction of moisture into said second stage scroll mechanism (1, 2).

7. A two-stage air-cooled, oil-free scroll mechanism comprising a scroll mechanism for compressing fluid, said scroll mechanism including a first stage (1, 3) and a second stage (1,2) scroll mechanism, fluid having been compressed in said first stage scroll mechanism being further compressed in said second stage scroll mechanism for discharging, said scroll compressor further comprising:

   fluid discharging means (14) disposed between said first stage and second stage scroll mechanisms, for suppressing load increase due to compressed fluid entering said second stage scroll mechanism.

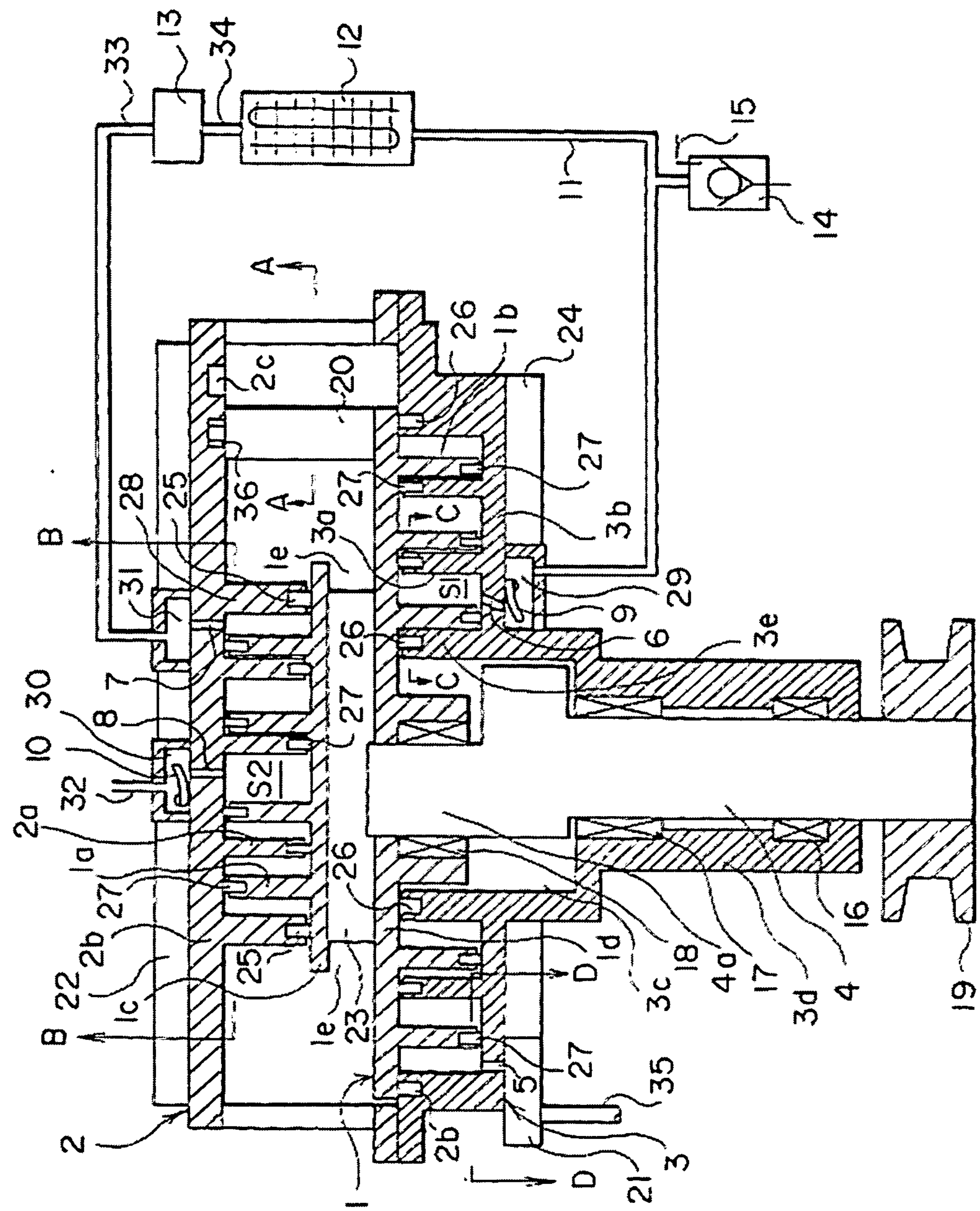
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FIG. 1

FIG. 2

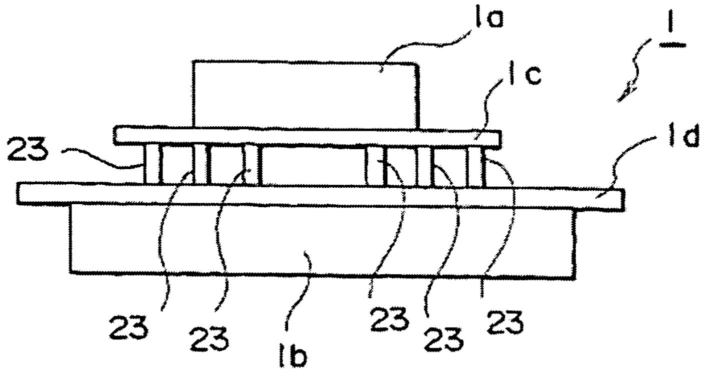


FIG. 3

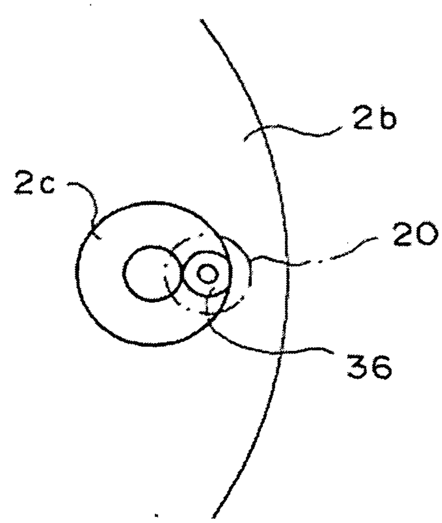


FIG. 4

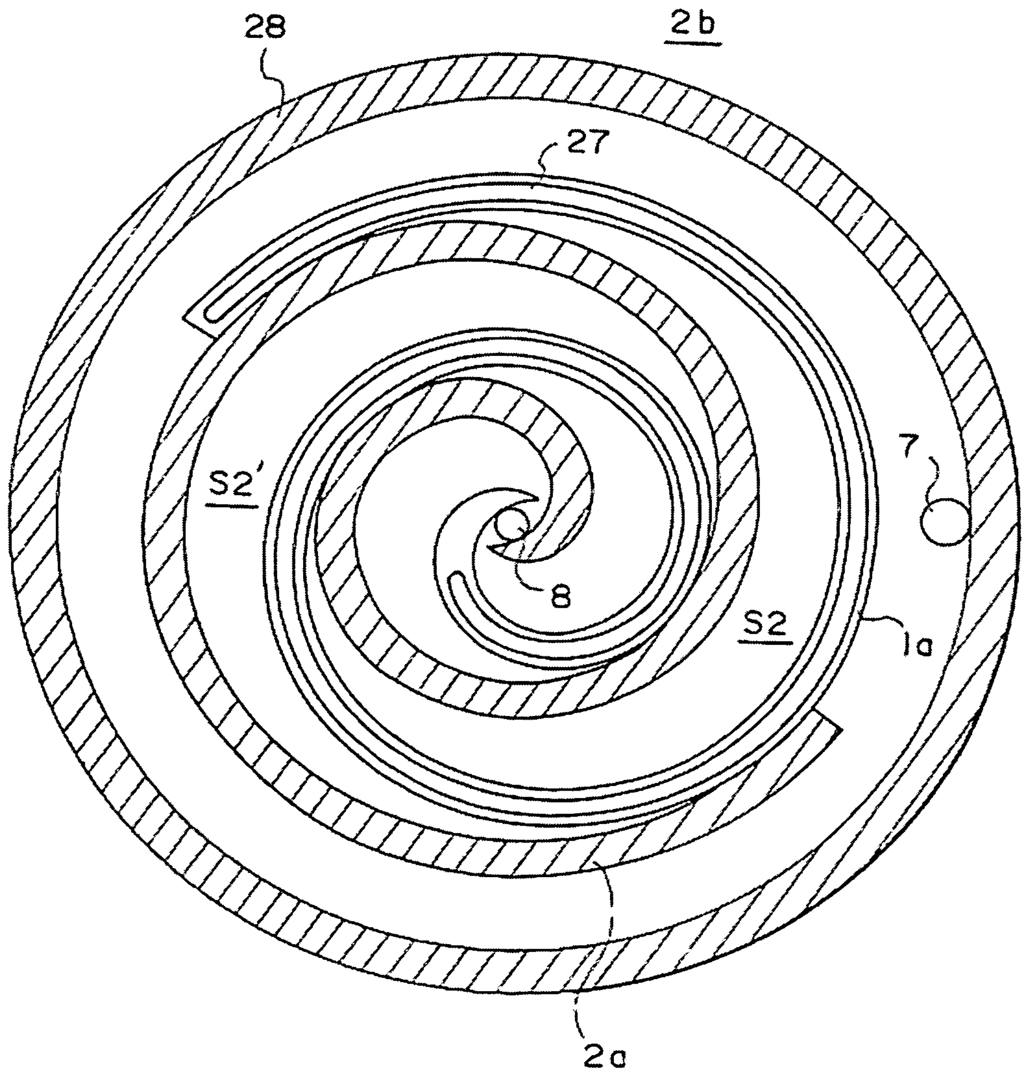


FIG. 5

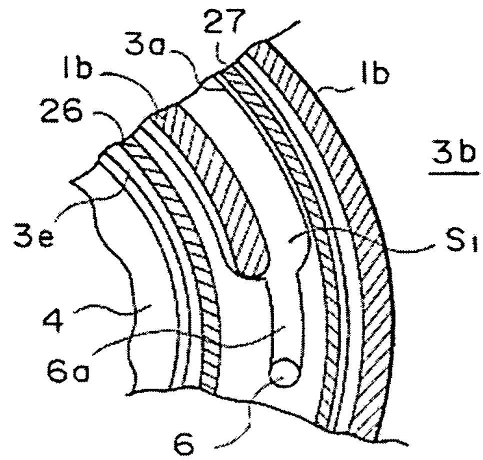


FIG. 6

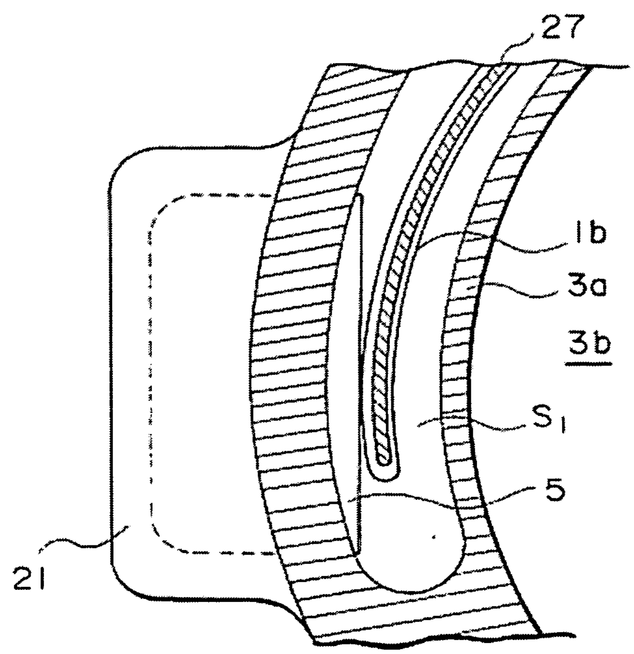
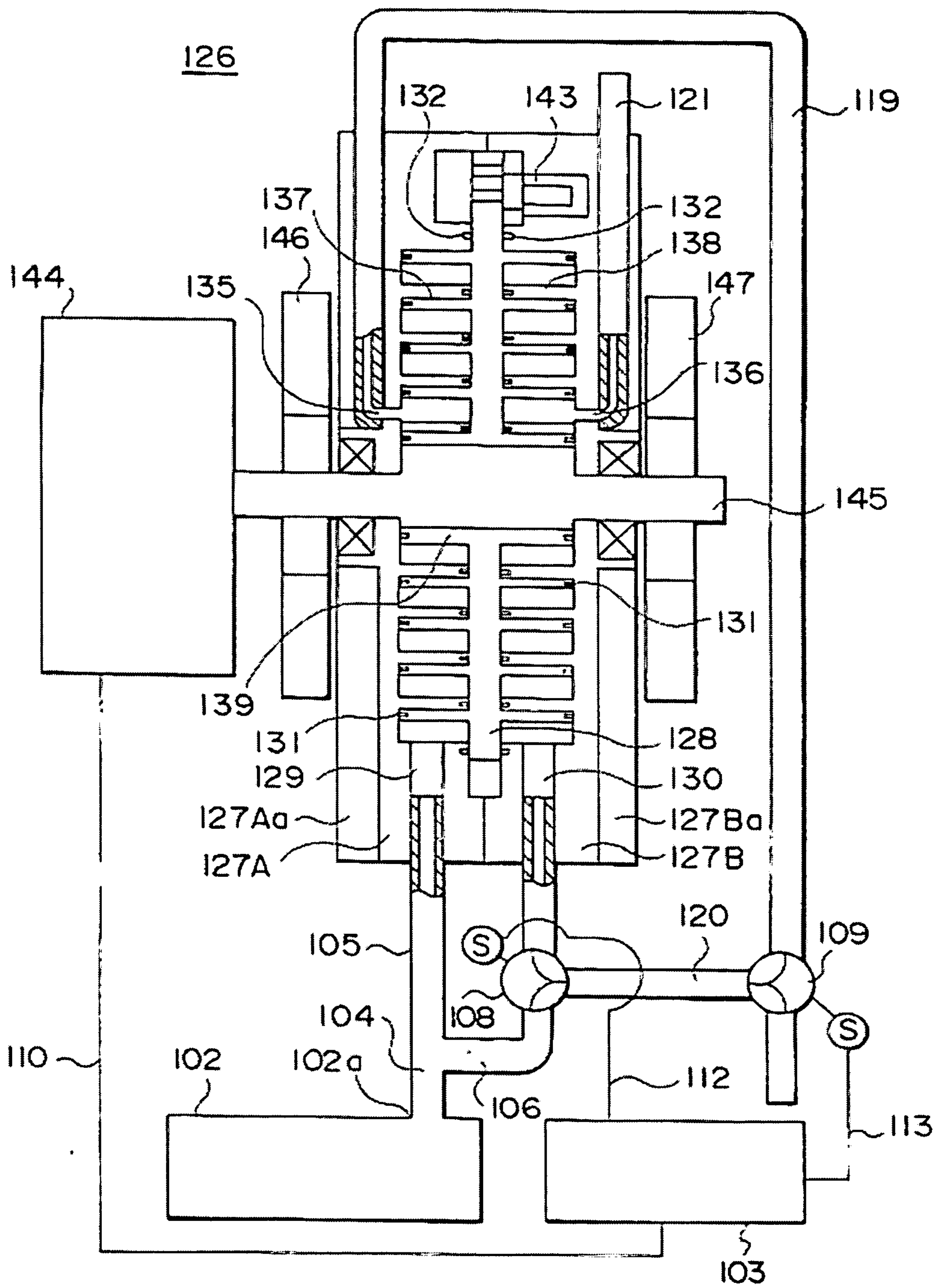


FIG. 7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127Ba
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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 3571

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	US 4 650 405 A (IWANAMI ET AL.) * column 4, line 10 - column 6, line 2; figure 1 *	1 2-5,7	F04C18/02 F04C29/08 F04C29/04 F04C29/10
X	US 5 173 042 A (CHAMBERS) * claim 1; figure 1 *	1	
X A	EP 0 728 947 A (S.B.P.V.) * column 5, line 48 - line 56; figure 1 *	1,4 5,7	
A	DE 195 28 070 A (KNORR-BREMSE SYSTEMEN FÜR SCHIENENFAHRZEUGE GMBH) * column 2, line 1 - line 34; figure 1 *	4	
A	FR 2 300 238 A (AGINFOR AG) * page 7, line 6 - page 10, line 23; figures 3,4 *	4	
A	PATENT ABSTRACTS OF JAPAN vol. 095, no. 007, 31 August 1995 & JP 07 103151 A (TOKICO LTD), 18 April 1995, * abstract *	4	**TECHNICAL FIELDS SEARCHED (Int.Cl.6)** F04C F01C
A	EP 0 342 057 A (SANDEN CO.) * claim 1; figure 1 *	4	
X A	EP 0 687 815 A (ASUKA JAPAN CO., LTD.) * column 9, line 38 - line 49; figure 3 *	5 7	
X	US 5 224 836 A (GUNN ET AL.) * column 2, line 68 - column 3, line 4 * * column 3, line 35 - line 43; figure 1 *	5,6	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 September 1997	Dimitroulas, P

CATEGORY OF CITED DOCUMENTS

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Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 097, no. 003, 31 March 1997 & JP 08 296573 A (MATSUSHITA ELECTRIC IND CO LTD), 12 November 1996, * abstract *	7	
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 276 (M-0984), 14 June 1990 & JP 02 081982 A (MATSUSHITA REFRIG CO LTD), 22 March 1990, * abstract *	7	
A	EP 0 529 660 A (DAIKIN INDUSTRIES LTD.)		
A	EP 0 730 093 A (IWATA AIR COMPRESSOR MFG. CO. LTD.)		
A	GB 1 007 236 A (THE JEAGER MACHINE CO.) * claim 1 *	7	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- [ ] Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

- [ ] No claims fees have been paid within the prescibed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

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- [X] All further search fees have been paid within the fixed time limit. The present Eurpean search report has been drawn up for all claims.

- [ ] Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

- [ ] None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

European Patent Office

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LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions, or groups of inventions, namely:

1.	Claims 1-3	:	Scroll compressor with discharge check valve.
2.	Claim 4	:	Two stage scroll compressor moving scroll.
3.	Claims 5,6	:	Two stage scroll compressor with intercooling by a heat exchanger.
4.	Claim 7	:	Two stage scroll compressor with fluid discharging means.